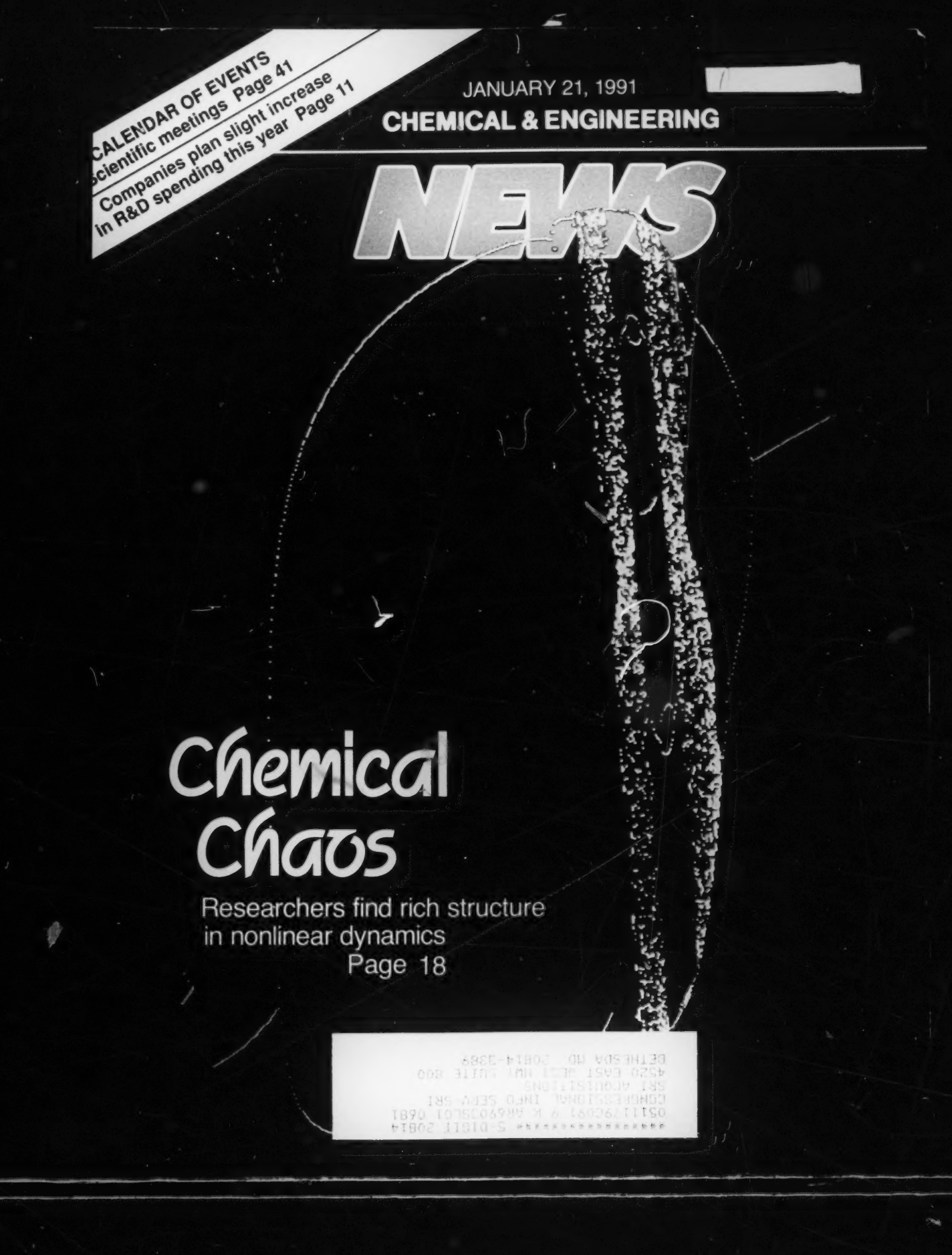
JANUARY 21, 1991
CHEMICAL & ENGINEERING

NEWS

CALENDAR OF EVENTS
Scientific meetings Page 41

Companies plan slight increase
in R&D spending this year Page 11



Chemical Chaos

Researchers find rich structure in nonlinear dynamics
Page 18

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JANUARY 21, 1991

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News of the Week

■ **Chemical and oil companies ready themselves for effects that the war in the Middle East will have on industry.** **Page 4**

■ **Suit seeks to block planned use of drugs lacking FDA approval on U.S. troops without their informed consent.** **Page 4**

■ **A number of prominent scientists join together to decry armed intervention in the Middle East.** **Page 5**

■ **Occidental Petroleum's new chief announces major restructuring in effort to carve $3 billion from its long-term debt.** **Page 5**

■ **FDA cuts its average drug review time nearly five months to 27.7 months, but this is still far from the six-month statutory standard.** **Page 6**

Business

Major U.S. chemical firms plan only 3% increase in R&D spending on average this year, in contrast to 8% in 1990, according to a recent C&EN survey. **Page 11**

Government

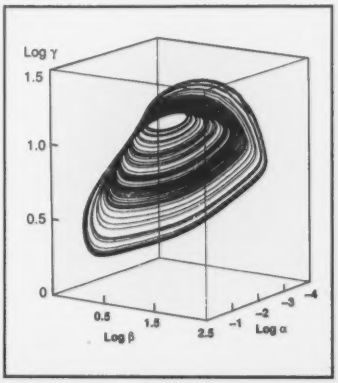
EPA finally issues drinking water standards for 38 more contaminants, and estimates cost of compliance by drinking water systems at a combined $88 million a year. **Page 15**

State precursor laws are proving very effective in curbing illegal drug making, but they have led to additional paperwork and reporting responsibilities for companies and laboratories. **Page 16**

Meetings

Calendar of meetings and events is semiannual listing of interest to chemists and chemical engineers. **Page 41**

Cover: Oscillatory reaction model shows period doubling leading to chaos (vertical bands) and subsequent return to periodic behavior. Calculation and photo by Bo Peng and Kenneth Showalter, West Virginia University



Science/Technology

Investigating chaotic chemical systems—ones that oscillate in concentration, potential, or another parameter—provides researchers with glimpses of ordered structure in systems previously thought inscrutable. **Page 18**

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Chemical & Engineering News
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LETTERS

CHEMICAL SAFETY

Rash from ruthenium complex

Two investigators in our laboratory have displayed an extreme sensitivity to [$RuCl(PMe_3)_2(Cp)$]. When handling the substance using normal benchtop Schlenk techniques, both developed severe rashes on exposed areas of the skin, especially on the face. We recommend that this compound be stored and handled in a glove box.

[$RuCl(PMe_3)_2(Cp)$] was prepared from [$RuCl(PPh_3)_2(Cp)$] and PMe_3 following published procedures [Bruce, M. I., Wong, F. S., Skelton, B. W., White, A. H., *J. Chem. Soc., Dalton Trans.*, 1398 (1981); Treichel, P. M., Komar, D. A., *Synth. Inorg. Met.-Org. Chem.*, **10**, 205 (1980)]. Neither of the starting materials produced a similar physiological reaction, nor did derivatives with PMe_2Ph, dppe, or $P(OMe)_3$ ligands.

John P. Selegue
George A. Koutantonis
Jeffrey R. Lomprey
University of Kentucky
Lexington

Biomass research

The letter on biomass research (C&EN, Nov. 19, 1990, page 2) reminds me of my experience in using wastes. About 1932, A. O. Smith Co. of Milwaukee, wanted to build prefabricated houses that were to sell for $3000, erected. They assigned to their research department the task of developing a material that could be fabricated into shapes required for the structure of prefabricated houses, and set a target cost per square foot of surface. The target cost was so low that the research group decided that only waste materials could be used, and a corrugated or hexagonal structure would be required, which meant a sheetlike material. The research group selected waste liquor from a paper mill and waste paper as the possible raw materials. The initial waste liquor used was the waste from a sulfite process paper mill.

A. O. Smith dropped that project, but it was carried on by a sulfite paper mill. A plant was built to produce the pulp, using waste wood and the sulfite waste liquor. It was run on the paper machine and pressed into panels. The pulp was also used to make phenolic molding compounds. At one time, this material was presented to Ford Motor Co., and Henry Ford came to that meeting and asked if the material could be pressed into a trunk door and withstand the blow of a sledgehammer. The answer had to be "no" to the blow from the sledgehammer. It was unfortunate that I did not know of Ford's interest in biomass products, for this was a biomass product.

Research was continued on the process. Instead of using the waste from a sulfite paper mill, black liquor was used from a kraft paper mill. The pulp was run on a small paper machine and the paper sheets were laminated. This laminated panel and a commercial phenolic laminate were tested using the standard testing procedure for this type of product. The specific gravity and the water absorption of the two panels were the same. The lignin laminate had 10% higher flexural and tensile strength and five times the resistance to impact compared to the phenolic sample. This lignin sample would have shown up much better in Ford's sledgehammer test.

The low cost of the waste raw materials, the availability of the high tonnage of both, and the use of this type of panel in the building industry show interesting possibilities. However, from the biomass research point of view, the organic chemicals in the black liquor are still in the waste liquor of this process and may be recovered more economically because of the absence of the lignin.

John G. Meiler
Cleveland, Tenn.

Lithium perchlorate solvent

In response to Baldur Föhlisch's letter (C&EN, Nov. 19, 1990, page 2) concerning the use of 5.0M lithium perchlorate in diethyl ether as a solvent for the Diels-Alder reaction, I believe it is appropriate to get the facts correct. Lithium perchlorate solutions in diethyl ether have been employed extensively over the years to accelerate reactions with polarized transition states. Over 30 years ago, Saul Winstein [*J. Am. Chem. Soc.*, **81**, 5111 (1959)] observed that the ionization rate of

Chemical Industry R & D Spending To Increase Modestly

Ten major chemical producers plan 3% hike in research expenditures this year, translating to only a 1% rise in constant-dollar terms

Marc S. Reisch,
C&EN Northeast News Bureau

Most major U.S. chemical and diversified companies plan to increase research and development spending in 1991, but at a slower pace than last year. C&EN's just-completed survey of 14 chemical companies shows that the 10 who did supply figures plan to increase R&D spending this year an average of only 3% over last year. According to the same survey, the 14 companies' most recent accounting estimates show that their R&D spending in 1990 increased an average of 8% over 1989.

The 3% increase for 1991 found in this survey agrees closely with Battelle Columbus Laboratories' just-released estimate of a 3.5% rise for all industry. Battelle bases its forecast on data drawn from National Science Foundation reports, federal budget documents, and other sources. The Columbus, Ohio-based technology organization projects total 1991 R&D spending by all U.S. industry will reach $155 billion, including that financed by government.

Battelle notes, however, that the real increase in R&D spending this year will be only 1% after factoring in inflation, which it estimates at 2.4% for 1991. Using Battelle's figure for R&D inflation to estimate this year's constant-dollar expenditures for the 10 chemical companies in C&EN's survey also yields only a 1% real increase.

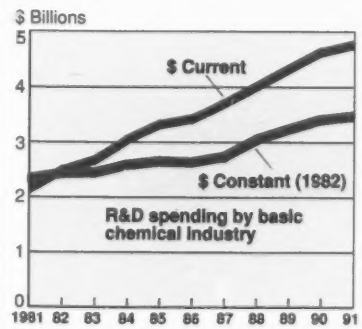
Battelle finds that the growth rate of domestic R&D expenditures has been slowing and is expected to continue in a period of uncertainty. For one, Battelle notes that decreases in defense procurement and the resulting profits will affect the availability of funds for R&D in some industries. Meanwhile, the nation's trade imbalance and efforts to correct it, along with efforts to expand some markets in response to shifts in government priorities, could lift R&D spending.

But Battelle continues to lament industry's overall emphasis in support of short-term R&D projects that seek short-term financial results rather than technical innovation. That trend will continue to have an adverse effect on the quality of R&D and amount of industry's investment in it, Battelle predicts.

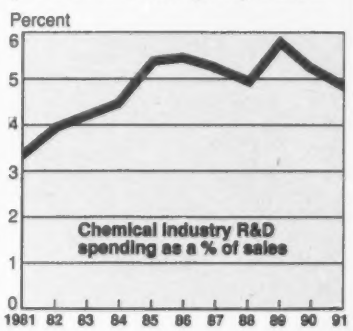
In the past few years, chemical companies have generally increased R&D spending at a much higher rate than all industry. In 1989, for example, C&EN found that the chemical companies it surveyed spent 8% more in 1989 than 1988, and Battelle forecast only a 3.4% increase for all industry that year (the latest data available). Still, it is important to note that the chemical industry continues to spend a much higher percentage of its sales on R&D (close to 6% in 1989 and almost 5% estimated in 1991) than industry as a whole (about 1.6% in 1989 based on C&EN estimates and the most recent Federal Reserve Board estimates).

The Chemical Manufacturers Association's recent poll of its membership shows that respondents plan to increase spending 5.5% in 1991 over 1990 levels. Since CMA's membership comprises both chemical and diversified companies, that estimate dovetails nicely with C&EN's survey results, in that it is midway between the 3% for chemical companies in C&EN's survey and 8% for the four diversified chemical producers who supplied projections of 1991 spending. Similarly, CMA's survey shows that members' R&D spending grew 9.1% in 1990, a little higher than the 8% that C&EN's survey found for chemical companies and much higher than the 3% growth for eight diversified companies that responded.

R&D spending is still on the rise . . .



. . . but continues to slip as percent of company sales



Note: For 14 chemical companies listed on page 13.
Sources: C&EN surveys and estimates, Battelle Columbus Laboratories

One difference in this year's C&EN survey and previous years' is the addition of two companies to the list of chemical firms surveyed—Lubrizol and Petrolite—and also the addition of two diversified companies—AT&T Bell Labs and Procter & Gamble. They have been included in an effort to broaden the survey. C&EN had hoped to include General Electric and IBM as well, but they couldn't estimate either 1990 R&D spending or 1991 plans at the time of the survey.

If IBM and General Electric were included in the survey, they would significantly expand the monetary pool on which R&D estimates for diversified companies are based. IBM, for instance, states in its 1989 annual report that it spent $5.2 billion on company-financed R&D that year, which was 8.3% of sales. General Electric says in its 1989 annual report that it devoted $1.3 billion to company-financed R&D efforts that year, which amounted to only 2.4% of sales. Both companies increased R&D spending substantially in 1989. IBM raised its spending almost 18% from 1988, following an 11% rise the previous year. And GE increased its R&D spending in 1989 16% from the previous year, following a 4% decline in 1988.

A number of foreign-owned firms also conduct a significant amount of chemical R&D in the U.S. but are not included in C&EN's tabulation. Until two years ago, SmithKline Beckman Corp. was regularly included in C&EN's annual survey of R&D spending. But with the 1989 merger with U.K.-based Beecham Group, to form SmithKline Beecham, the company now reports its figures in British sterling, although the bulk of the new company's research effort is still in the U.S. Currency translations can significantly alter the increase or decrease in budgets. Although the company reports it invested £390 million in R&D in 1990 and company sources assume it will spend the same amount in 1991, the British pound has appreciated 15% during the past year, swelling the dollar budget by a like amount.

German chemical companies with major investments in the U.S. will continue to benefit from the effects of currency appreciation (up 10% during 1990) when they exchange deutsche marks to pay for research undertaken in the U.S. Bayer Group says it increased its R&D worldwide from 2.7 billion deutsche marks in 1989 to 2.8 billion in 1990—a 3.6% increase.

Hoechst boosted its R&D spending 7.7% in 1990 to 2.8 billion deutsche marks, the same budget as Bayer. According to Utz-Hellmuth Felcht, vice president of Hoechst Celanese and president of its advanced technology group, the 1991 budget worldwide will probably rise only enough to adjust for inflation and salary cost increases.

In the U.S., Hoechst Celanese will increase its R&D budget from $244 million in 1990 to $255 million in 1991 in support of the life sciences, high-performance polymers, and technical fibers and films that are the major focus of the advanced technology group. This roughly 5% increase follows an almost 10% yearly increase in 1990 and is meant to add the cost of inflation and salary cost increases to the budget while still giving U.S. operations a "modest growth and a safety net," says Felcht. The company will continue its efforts, he adds, to recruit new scientists from universities at the same level as last year. "The worst thing you can do is to hire in good years and stop in bad years, because you lose your reputation for reliability."

Phillips 66 technician inspects K-Resin butadiene-styrene copolymer samples made at new pilot plant at R&D center

Among specific chemical companies in this year's C&EN survey, Air Products & Chemicals plans the biggest increase in R&D spending with a 9.7% rise from 1990 to $79 million. The 1991 increase follows a 1.4% increase the year before. W. R. Grace plans the second biggest gain in 1991, with its R&D funding rising 7.1% to $150 million. That increase follows a 12% rise the year before when the company figures it spent $140 million on R&D.

PPG Industries has budgeted moderate growth for its R&D spending in 1991 with a hike of 6.4% planned to $250 million. This follows about a 1% increase in 1990 to $235 million. Union Carbide plans to raise its R&D spending 5.3% in 1991 to $200 million after increasing its spending 5% last year.

Both American Cyanamid and

R&D inches up as percent of future-oriented spending

Total 1990 = $13.7 billion **Total 1991 = $13.5 billion**

Note: Based on C&EN surveys and estimates of 12 major chemical companies listed on page 13 (Petrolite and Lubrizol are excluded because they were not included in the 1991 capital spending survey).

Major chemical companies plan 3% increase in R&D spending this year

$ Millions	Planned 1991	Actual 1990	Planned 1990	1989	1988	1987	1986	1985	Change from previous year 1991	Change from previous year 1990	R&D spending as % of sales 1991	R&D spending as % of sales 1990
CHEMICAL COMPANIES												
Air Products[a]	$ 79	$ 72	$ 71	$ 71	$ 72	$ 57	$ 61	$ 51	9.7%	1.4%	2.6%	2.5%
American Cyanamid	479	458	450	406	365	314	278	251	4.6	12.8	9.0	9.2
Dow Chemical	1180	1150	950	873	772	670	605	547	2.6	31.7	6.1	6.3
Du Pont[b]	1220	1350	1380	1387	1319	1223	1156	1144	-9.6	-2.7	5.2	6.1
Ethyl[c]	68	65	65	61	59	50	47	47	4.6	6.6	4.1	4.2
W. R. Grace	150	140	145	125	119	107	94	92	7.1	12.0	2.2	2.2
Hercules	na	89	na	79	74	74	71	76	na	12.7	na	2.8
Lubrizol	na	73	na	70	65	62	51	44	na	4.3	na	5.8
Monsanto	na	625	na	598	575	557	523	470	na	4.5	na	7.0
Olin	na	65	65	66	58	62	56	53	na	-1.5	na	2.5
Petrolite	12	12	na	12	12	12	12	12	0	0	3.7	4.0
PPG Industries	250	235	250	233	227	227	204	176	6.4	0.9	4.0	4.0
Rohm & Haas	185	180	180	175	156	142	133	124	2.8	2.9	6.3	6.6
Union Carbide	200	190	na	181	159	159	148	275	5.3	5.0	2.1	2.1
TOTAL	**$3823**	**$4704**	**$3556**	**$4337**	**$4032**	**$3716**	**$3439**	**$3362**			**4.8%**	**5.2%**
ANNUAL CHANGE[d]	**3%**	**8%**		**8%**	**9%**	**8%**	**2%**	**10%**				
DIVERSIFIED COMPANIES												
Allied-Signal[e]	700	700	650	603	647	400	360	298	0	16.1	5.3	5.7
Arco Chemical	na	na	na	52	39	29	32	29	na	na	na	na
AT&T Bell Labs	na	2400	na	2652	2572	2453	na	na	na	-9.5	na	6.5
Eli Lilly	na	700	na	605	500	466	427	370	na	15.7	na	16.3
FMC	140	158	155	150	144	132	146	149	-11.4	5.3	3.7	4.5
Merck & Co.	na	855	na	751	650	566	480	426	na	13.8	na	12.7
Morton International[e,f]	60	48	50	38	35	31	29	na	25.0	26.3	3.9	3.3
Procter & Gamble[e,g]	na	693	na	628	615	549	479	na	na	10.4	na	2.8
Schering-Plough	420	370	370	327	298	251	212	189	13.5	13.1	12.1	11.4
TOTAL	**$1320**	**$5924**	**$1225**	**$5806**	**$5500**	**$4877**	**$2165**	**$1461**			**6.0%**	**6.3%**
ANNUAL CHANGE	**8%**	**3%**		**6%**	**13%**	**12%**	**13%**	**11%**				

a For fiscal year ended Sept. 30. b All figures exclude Conoco. c 1989, 1990, and 1991 figures adjusted to reflect spin-off of Tredegar Industries in July 1989. d For those companies reporting. e Includes all company-financed R&D, but excludes contract R&D. f Fiscal year ended June 30. Figures adjusted to 1986 in order to reflect division of Morton Thiokol into Morton International and Thiokol Corp. in July 1989; 1985 figures are for Morton Thiokol. g Fiscal year ended June 30. na = not available.

Ethyl plan 4.6% increases in their R&D spending levels in 1991. Cyanamid plans to boost its spending to $479 million following a 13% increase the previous year. The Cyanamid figures for 1991 exclude spending for Shulton Group, which Cyanamid sold during 1990. About $30 million of the 1990 R&D budget involved spending for Shulton Group. Ethyl's planned 1991 increase in R&D expenditures to $68 million follows a 6.6% increase the previous year.

Several companies fell below the average increase for the 10 chemical companies that supplied 1991 figures. Rohm & Haas plans to increase R&D spending 2.8% this year to $185 million, following a 2.9% increase last year. Dow Chemical plans only a modest increase of 2.6% in 1991 to $1.2 billion, following a 32% increase last year. Petrolite's R&D budget will remain unchanged in 1991, frozen at the same level since 1984.

Du Pont has budgeted a significant decrease in its R&D spending for 1991. The company plans to spend $1.2 billion, down a hefty 9.6% from last year. This decline follows a smaller 2.7% drop in spending last year.

Hercules, Lubrizol, Monsanto, and Olin were unable to provide an early estimate of their R&D spending for 1991. However, all three supplied estimates of their 1990 spending. Hercules' 1990 R&D spending rose 13% from 1989 to $89 million. Monsanto increased its 1990 spending 4.5% to $625 million, and Lubrizol boosted its spending 4.3% to $73 million. Olin, however, reported a net decline in 1990 R&D spending to $65 million.

Among chemically related diversified companies, four providing 1991 spending estimates—Allied-Signal, FMC, Morton International, and Schering-Plough—plan to increase their R&D budgets an average of 8% this year. Their figures include internally generated R&D projects only and not government contracts. Of the four, Morton International plans the largest increase: 25% to $60 million, following a 26% increase in 1990. Schering-Plough, the pharmaceuticals manufacturer, plans the second largest increase among the four, 14% to $420 million, following a 13% increase in 1990. □